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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

General Motors Corporation

M E M O R A N D U M

January 5, 1995

EX PARTE OR LATE FILED

TO: William F. Caton
Secretary of the Federal Communications Commission

FROM: William J. Chundrlik, Jr.
General Motors Corporation

RE: Ex Parte Presentation
ET Docket No. 94-124
RM 8308

This memorandum and the attached materials summarize an ex parte presentation made on this day to Dr. Michael J. Marcus and Richard Engelman of the Office of Engineering and Technology. The presentation was made by Nicholas P. Morenc of HE Microwave and myself. We were accompanied by Paul Fox, P.E. of Telecommunications Directions and Erika Z. Jones of Mayer, Brown & Platt. The ex parte presentation concerned technical issues related to the development of vehicular radar systems, and is completely reflected in the attached materials, except that certain limited portions of the presentation contained proprietary information. General Motors has submitted a request for confidential treatment for the proprietary information to Mr. Smith, Chief of the Office of Engineering and Technology, pursuant to Section 0.459 of the Commission's Rules. A copy of that letter is attached to this submission.

The confidential information has been redacted from the materials attached to this memorandum. Accordingly, this memorandum and the attached materials are appropriate for inclusion in the public docket.

cc: Dr. Marcus
Mr. Engelman

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List A B C D E

Agenda

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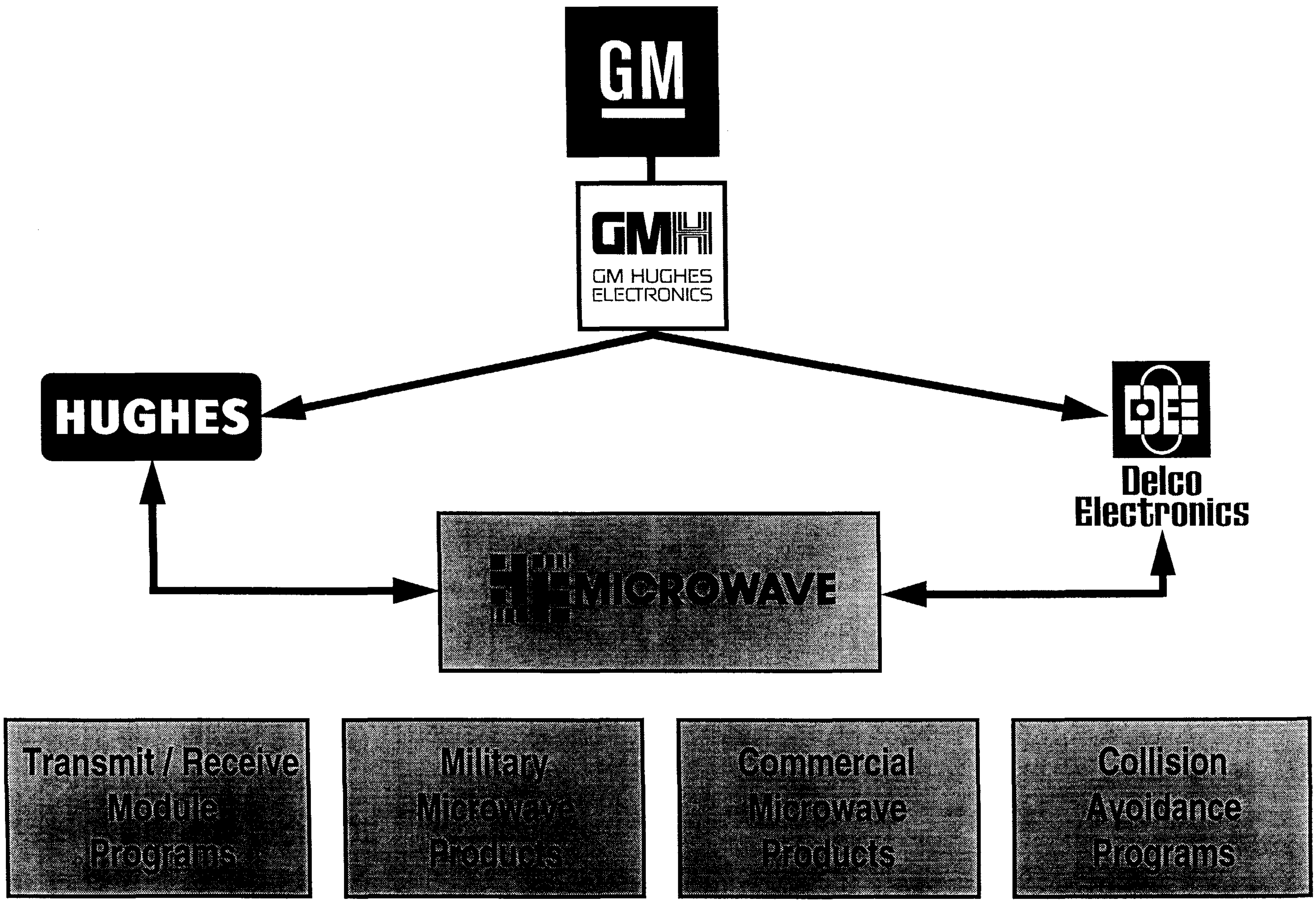
- Introduction
- Forward looking radar (FLR)
- Public interest aspects
- Regulatory considerations
- Summary
- Technical appendices
  - Probability of false alarms
  - FLR design considerations
  - FMCW radar overview
  - Loss of detection sensitivity due to non-synchronized sources



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About GM

General Motors has operations in 53 countries and worldwide employment averaging 711,000 people, including 448,000 in the United States. Best known as a full-line vehicle manufacturer, GM had worldwide factory sales in 1993 of more than 7.8 million motor vehicles, of which approximately 4.7 million were domestic sales. GM manufactures and sells cars and trucks worldwide through a variety of nameplates, including Chevrolet/Geo, Pontiac, Oldsmobile, Cadillac, GMC Truck, Saturn, Opel, Vauxhall, Holden, Isuzu and Saab.

But vehicles are not our only product. General Motors is also a major producer of automotive components and systems and non-automotive products and services.

GM is organized around six key business sectors:

- Our **NORTH AMERICAN OPERATIONS** (NAO) includes the following groups:
  - — Small Car Group, which includes Lansing Automotive Division and Saturn Corporation
  - — Midsize and Luxury Car Group, which includes Midsize Car Division and Cadillac/Luxury Car Division
  - — North American Truck Group, which manufactures small and full-size pick-up and utility vehicles, medium and large vans, and medium-duty trucks
  - — GM Powertrain Group, which includes engine, transmission and foundry operations
  - — Vehicle Development and Technical Operations Group, which includes the GM Research and Development Center, Design and Engineering Centers, Manufacturing Center and the Metal Fabricating Division

  In addition, NAO includes Worldwide Purchasing; Service Parts Operations; and sales, service and marketing for nameplates built in the United States and Canada.

- Our **INTERNATIONAL OPERATIONS** (IO) includes GM Europe, Adam Opel, Vauxhall, Saab Automobile, GM do Brasil, as well as operations in Latin America and Africa and in the Mideast Asia/Pacific region.

- Our **AUTOMOTIVE COMPONENTS GROUP WORLDWIDE** (ACGW) supplies components and systems to every major automotive manufacturer. Divisions include: AC Delco Systems, Delco Chassis, Harrison, Inland Fisher Guide, Packard Electric and Saginaw.

- **GM HUGHES ELECTRONICS** (GMHE), which includes Delco Electronics Corporation and Hughes Aircraft Company, is a specialist in automotive electronics, commercial technologies, telecommunications, and space and defense electronics.

- **ELECTRONIC DATA SYSTEMS** (EDS) is a leader in developing and applying information processing technologies around the world.

- **GENERAL MOTORS ACCEPTANCE CORPORATION** (GMAC) and its subsidiaries provide financial, investment and insurance services to retail customers and automotive dealers.

October 1994

Automotive Radar Programs- Forewarn

- School Bus
  - Radar detects children in danger zones of school buses and alerts school bus driver–in production
- Side detection systems (SDS)
  - Radar detects hazards in blind zones of vehicle
- Rear detection system
  - Radar detects objects behind car when in reverse
- Foward Looking Systems
  - In-path collision warning
  - Enhanced cruise control (ECC)
  - Adaptive cruise control (ACC)

Forward Sensor Requirements: Vehicle Systems Applications

- In-Path Collision Warning
  - Visual and audible warnings - no automatic control
  - Highway/freeway operation
- Enhanced cruise control
  - Maintains speed dependent distance
  - Highway/freeway operation
  - Accelerator input only
- Adaptive cruise control
  - Maintains speed dependent distance
  - Accelerator and brake control
  - Highway/freeway operation
- Crash avoidance vehicle control
  - Maintains speed dependent distance
  - Accelerator, brake and steering control
  - Visual, audible, and other warnings
  - Highway/freeway and urban operation

Proposed Forewarn System Rollout

Calendar Year	System	Year Design Frozen
93	School Bus (2 Sensors)	—
95	Commercial Vehicle Side Detection	94
96	Commercial Vehicle Rear Detection	95
96	Commercial Vehicle In-Path DA	95
97	Automotive Side/Rear (Production begins in '96)	95
98	Automotive ECC (Production begins in '97)	96
99+	Automotive ACC (Production begins in '98)	97+

Automotive Radar Application Issues

- Performance requirements
- Packaging, i.e., aperture size and location
- Driver interface
- Cost

Chronology of Forward-Looking Radar Programs

- Automotive Sensor Instrumentation System (ASIS) Van
  - 9/86 – 5/89
  - Sensors, data recording equipment used to determine technical requirements
- Adaptive Cruise Control (ACC) Radar, Concept I
  - 8/89 – 11/91
  - 60 GHz, testbed for hardware, signal and data processing algorithms
- ACC Concept II
  - 6/92 – present
  - 76 GHz, new antenna technology, higher level of integration in transceiver
- GMHE Forward-Looking Radar (FLR)
  - 10/93 – present
  - 76 GHz, cost and size reduction vis-a-vis ACC

Basic Performance Goals

- Detect nearest in-path target, provide alarm in hazardous situations
- Minimize false alarms from bridges, overhead signs, guardrails, etc.
- Maintain track on in-path target in a curve
- Provide driver with appropriate level of situational cues (human factors engineering)
- All weather performance

Principal Design Parameters for FLR's

- Maximum and minimum range & range rate
- Range & range rate resolution and accuracy
- Angular field of view (FOV)
- Beamwidth (BW)
- Carrier frequency
- Antenna size (tradeoff among FOV, BW, frequency, packaging)
- Modulation scheme
- Target update time (elapsed time between sequential "looks")

Potential Public Interest Benefits of Multiple Frequency Allocations

- AAMA has proposed that the FCC allocate several frequency bands for automotive radar
- GM/Delco/Hughes supports the AAMA position in favor of multiple frequencies
- Cost and performance of automotive radar devices are affected by the particular frequency for which they are designed, and different devices will balance these parameters in different ways
- Allocating multiple frequencies will permit development of a variety of radar designs for evaluation by government and industry, and will encourage competition

Forward-Looking Radar Bandwidth Considerations at 76 GHz

- Increased bandwidth reduces probability of interference between forward-looking radar units
  - Probability of false alarms by FMCW systems is essentially inversely proportional to bandwidth allowed in model detailed in Technical Appendix A
- Increased bandwidth significantly reduces cost of manufacture
  - Given large public benefits from forward-looking radars, minimizing cost is appropriate
  - Cost estimates based on HEM history with 10-GHz production program
- At 76 GHz, 1000 MHz bandwidth is appropriate choice

Frequency Allocation Bandwidths

Center Frequency	Bandwidth	% Bandwidth
10.525 GHz	50 MHz	.475 %
24.125 GHz	250 MHz	1.036 %
76.50 GHz	1000 MHz	1.307 %

Why 76 GHz?

- Best compromise between cost and performance
  - Prior HEM experience has shown that 60 GHz and below cannot achieve sufficiently narrow beamwidth within acceptable aperture size
  - Improvement in aperture size by using higher frequency may not offset higher component costs imposed
- Benefits of harmonization with Europe aid American exports, especially by smaller firms
- Eliminates unnecessary non-tariff trade barriers and contributes to the manufacture and marketing of the "world car," i.e., a car that can meet the technical standards of both Europe and the United States

Interference Between Two Like Systems

- Two similar systems could produce false target indications if:
  - Synchronized in time, and
  - Sufficiently close in RF center frequency, and
  - Antennas are looking at each other
- The GMHE system employs:
  - Coherent processing: requires synchronization of transmitted signal and received signal
  - Narrow detection bandwidth: minimizes interference bandwidth

Interference Rejection Capabilities

- False alarm rate due to mutual interference (See Appendix A)
  - Model assumes a generic FMCW design
  - Only three interference-reducing factors considered
    - Synchronization in time
    - Identical frequency of operation within allowed band
    - Antennas looking at each other
  - Model results are function of allowed system bandwidth
  - With operating bandwidth of 900 MHz:
    - One false alarm per 230,000 hours
- Interference due to CW interferer at 100m: 17 dBM CW with 3° BW reduces detection range to 75 meters (See App. D)

Nuisance Alarm Abatement

- Multiple target tracking
  - All targets within the entire radar FOV are tracked, i.e., the range, range rate, and angular location of each target are continuously measured
  - The track information facilitates threat assessment by providing a history of target
- Vehicle path prediction (VPP) using supplemental information—currently the steering wheel angle is used to infer vehicle turns, thus enabling a prediction of the "vehicle path"
  - Forms the basis of an in-path "target selection" algorithm
  - Aids threat assessment

False Alarm Abatement

- Narrow beam—reduces sensitivity to directional interference signals
- Low side-lobe sensitivity—de-sensitizes radar to objects/signals not in the beam
- Decreased sensitivity to electronic noise due to
  - Coherent signal processing—insensitive to signals not coherent with respect to the reference signal generated by the radar
  - Noise-adaptive thresholding—accounts for noise variation

Automotive Radar: Potential Customer Benefits

- Enhanced highway safety
  - Early alert to potential obstacle/collision
  - Daimler-Benz study showed that one-half second additional driver reaction time could reduce rear-end collisions by 60%
- Improved driver convenience
- May reduce insurance rates

All major OEM's are in evaluation or development of automotive radar applications

Public Interest Benefits of Collision Avoidance

- Motor vehicle safety
  - Collision avoidance systems will enhance motor vehicle safety
  - The Department of Transportation/National Highway Traffic Safety Administration supports the development and introduction of collision avoidance systems
- Intelligent Vehicle-Highway System
  - Collision avoidance radar is a key element of IVHS
  - Congress has made IVHS implementation a national goal in enacting the Intelligent Vehicle-Highway Systems Act of 1991
- Redirection of Defense Technology for Civilian Use
  - Manufacturing collision avoidance systems will help create jobs in the U.S.
  - Prompt approval of spectrum allocation will help maintain the U.S. lead in the development of collision avoidance technology

Regulatory Considerations

- Exclusive allocations are not required for GMHE system
- Authorizing several frequencies will permit the development of different collision avoidance technologies
- Benefits of 76 GHz band
  - Harmonization
  - Lowest cost at acceptable size
- Leadtime requires speedy allocation of spectrum for automotive use

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Conclusions

- The public interest will be well served by the introduction of automotive radar systems
- Automotive radar systems will enhance motor vehicle safety
- Automotive radar is an excellent example of the deployment of defense technology for civilian use
- Automotive radar is a key component of the intelligent vehicle highway system
- The FCC should promptly complete rule making to allocate spectrum for automotive radar applications by mid-1995 in order to permit the introduction of automotive radar systems beginning in model year 1997

Technical Appendix A

Forward-Looking Radar Interference Analysis: Probability of False Alarms